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Wilssens

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(54) **SERVER-SIDE RENDERED AUDIO USING CLIENT AUDIO PARAMETERS**

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(51) **Int. Cl.**
H04L 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 65/602*** (2013.01); ***H04L 65/1059*** (2013.01); ***H04L 65/1063*** (2013.01); ***H04L 67/42*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 65/602; H04L 65/1059; H04L 65/1063; H04L 67/42
See application file for complete search history.

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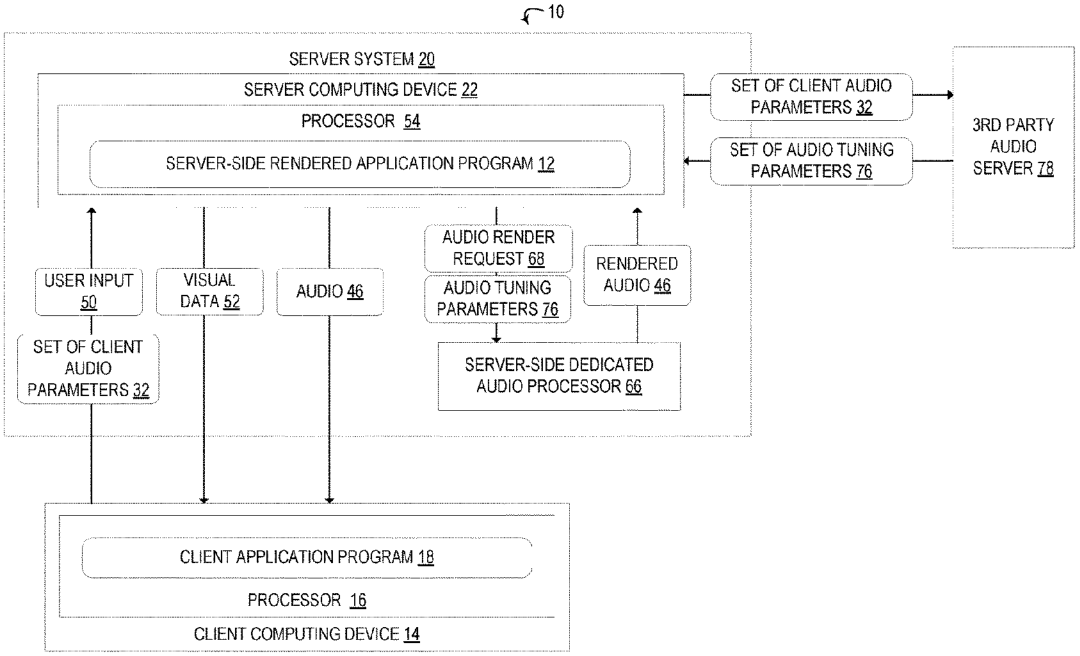
(57) **ABSTRACT**

A server system is provided that includes at least one processor configured to receive a set of client audio parameters from a client computing device, determine a set of audio tuning parameters based on the set of client audio parameters, execute a server-side rendered application program for the client computing device, render a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device, render a stream of audio for the server-side rendered application program based on the set of audio tuning parameters, and send the stream of visual data and the stream of audio to the client computing device.

20 Claims, 6 Drawing Sheets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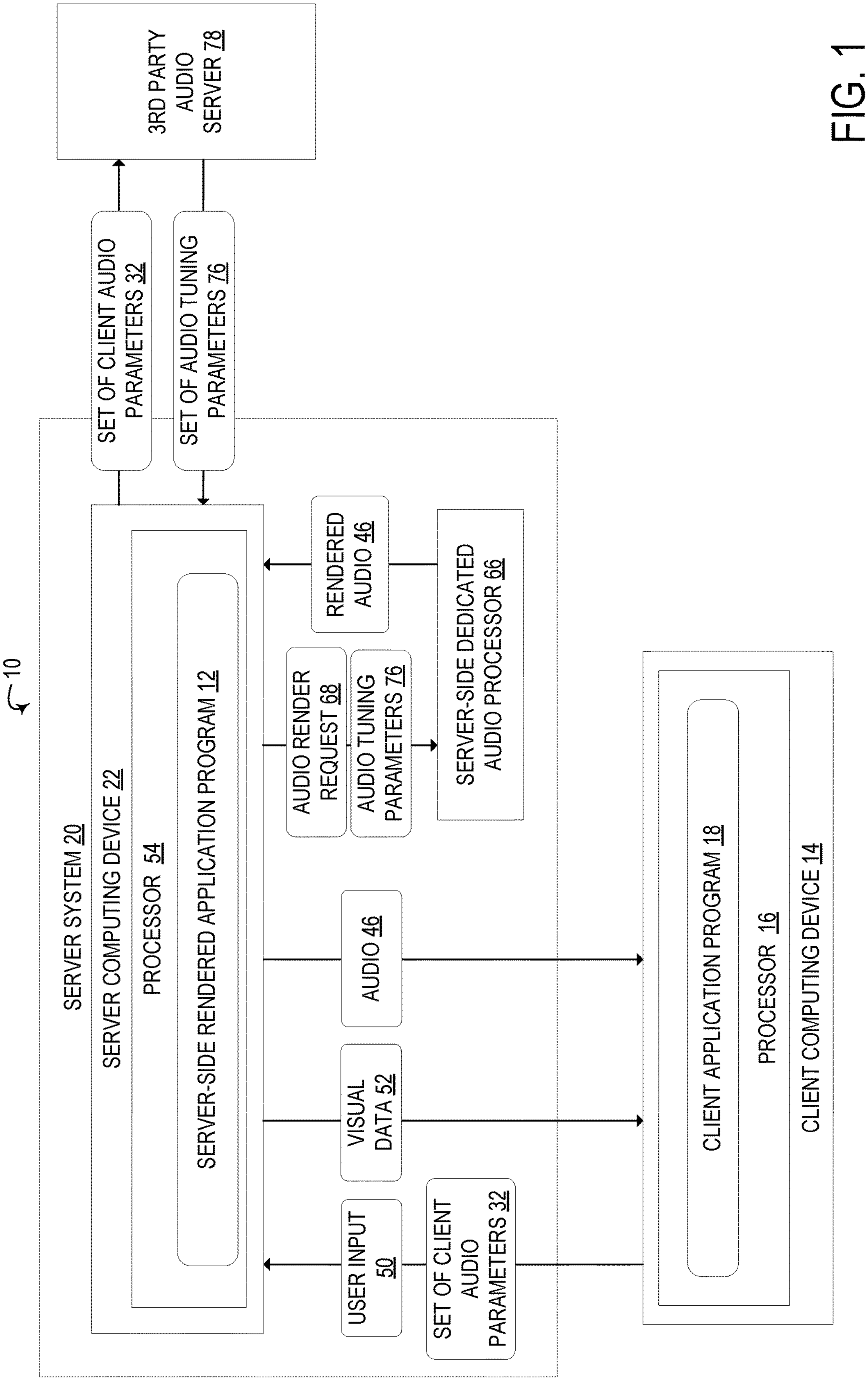
PROCESSOR 54
SERVER-SIDE RENDERED APPLICATION PROGRAM 12
SET OF CLIENT AUDIO PARAMETERS 32
SET OF AUDIO TUNING PARAMETERS 76
3RD PARTY AUDIO SERVER 78
USER INPUT 50
VISUAL DATA 52
AUDIO 46
AUDIO RENDER REQUEST 68
AUDIO TUNING PARAMETERS 76
RENDERED AUDIO 46
SET OF CLIENT AUDIO PARAMETERS 32
SERVER-SIDE DEDICATED AUDIO PROCESSOR 66
CLIENT APPLICATION PROGRAM 18
PROCESSOR 16
CLIENT COMPUTING DEVICE 14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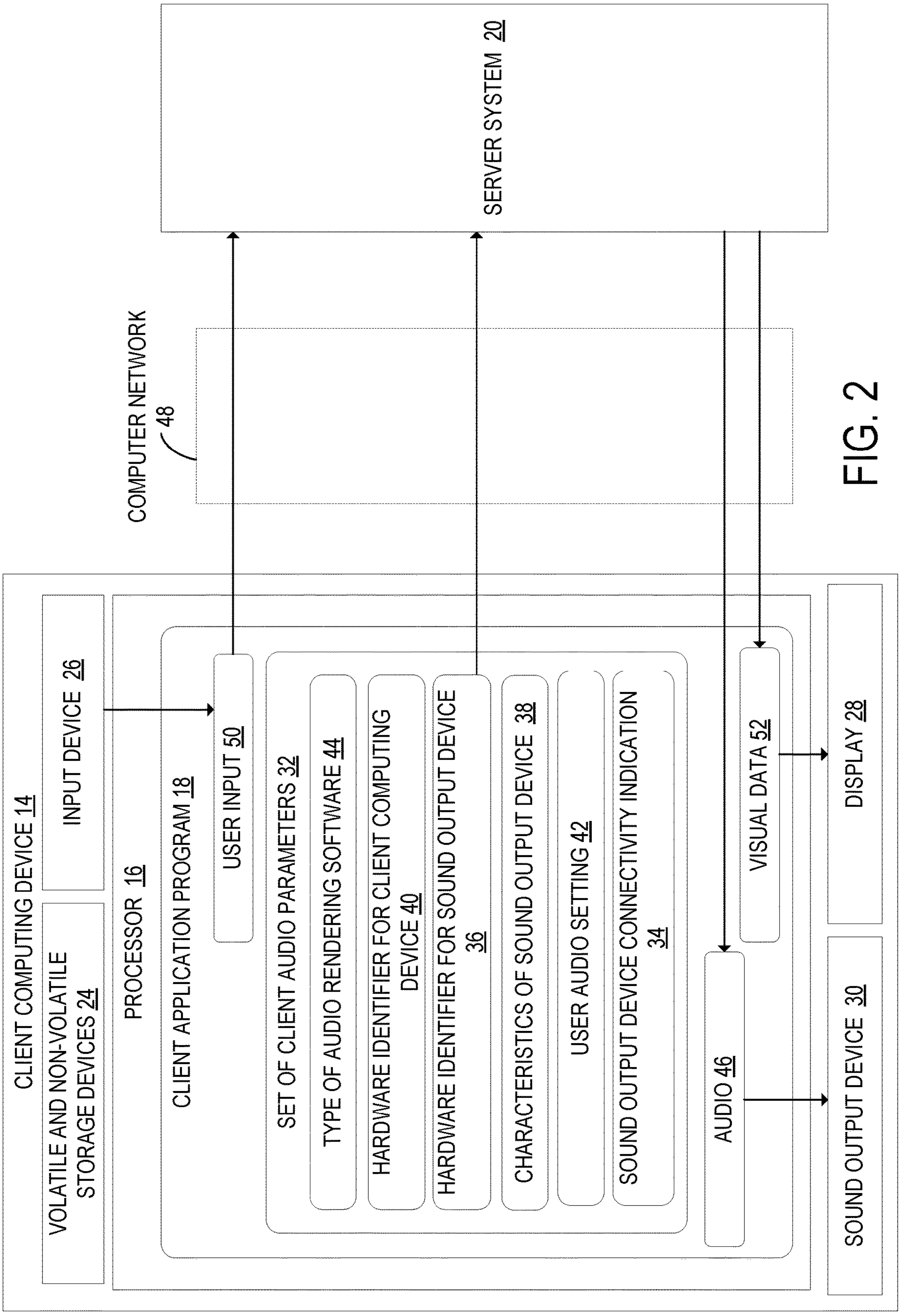
PROCESSOR 54
SERVER-SIDE RENDERED APPLICATION PROGRAM 12
SET OF CLIENT AUDIO PARAMETERS 32
SET OF AUDIO TUNING PARAMETERS 76
3RD PARTY AUDIO SERVER 78
RENDERED AUDIO 46
SERVER-SIDE DEDICATED AUDIO PROCESSOR 66
AUDIO RENDER REQUEST 68
AUDIO TUNING PARAMETERS 76
AUDIO 46
VISUAL DATA 52
USER INPUT 50
SET OF CLIENT AUDIO PARAMETERS 32
CLIENT APPLICATION PROGRAM 18
PROCESSOR 16
CLIENT COMPUTING DEVICE 14

FIG. 1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VOLATILE AND NON-VOLATILE STORAGE DEVICES 24
INPUT DEVICE 26
PROCESSOR 16
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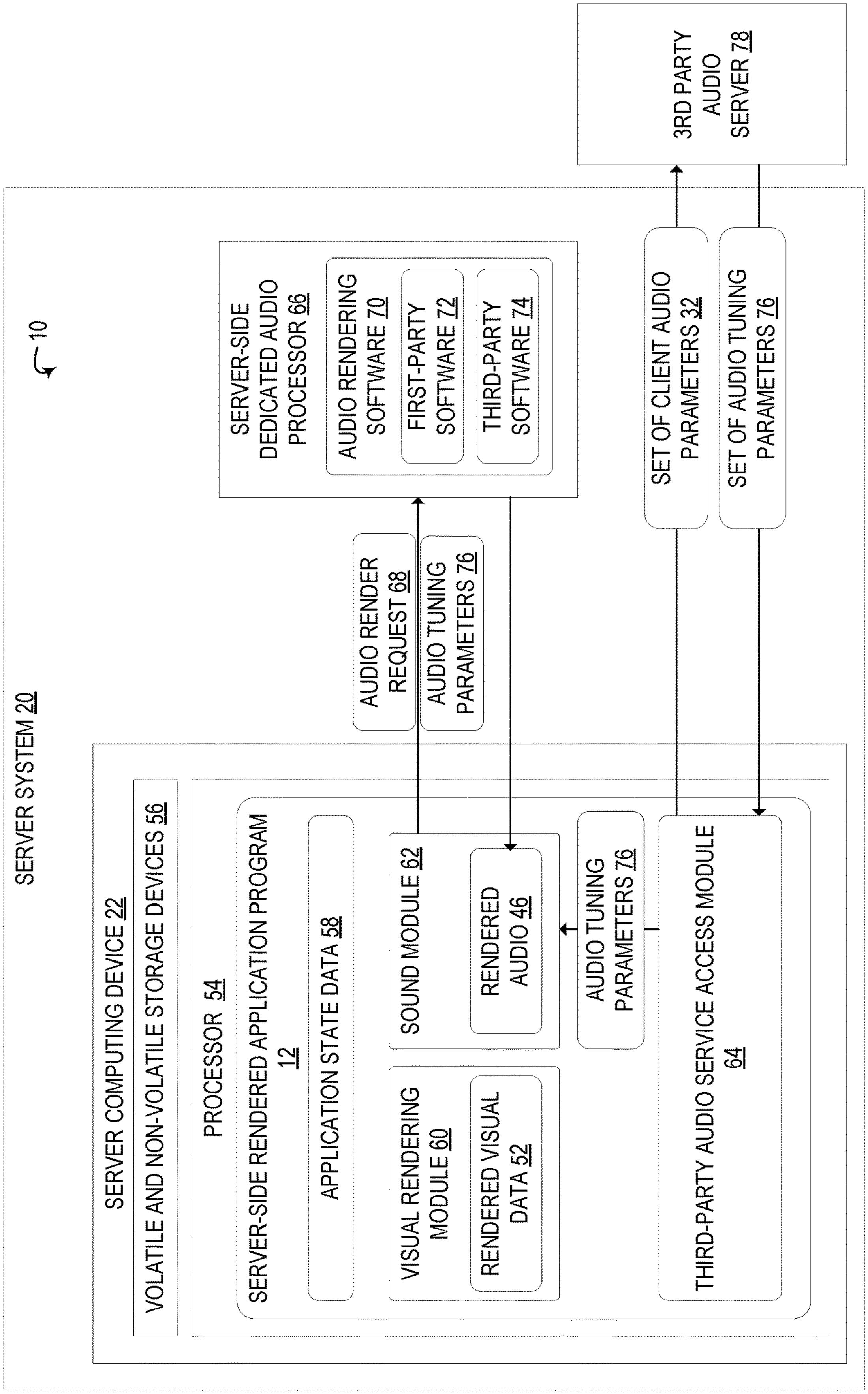
USER INPUT 50
SET OF CLIENT AUDIO PARAMETERS 32
TYPE OF AUDIO RENDERING SOFTWARE 44
HARDWARE IDENTIFIER FOR CLIENT COMPUTING DEVICE 40
HARDWARE IDENTIFIER FOR SOUND OUTPUT DEVICE 36
CHARACTERISTICS OF SOUND OUTPUT DEVICE 38
USER AUDIO SETTING 42
SOUND OUTPUT DEVICE CONNECTIVITY INDICATION 34
AUDIO 46
VISUAL DATA 52
SOUND OUTPUT DEVICE 30
DISPLAY 28
COMPUTER NETWORK
48
SERVER SYSTEM 20

FIG. 2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PROCESSOR 54
SERVER-SIDE RENDERED APPLICATION PROGRAM 12
APPLICATION STATE DATA 58
VISUAL RENDERING MODULE 60
RENDERED VISUAL DATA 52
SOUND MODULE 62
RENDERED AUDIO 46
AUDIO TUNING PARAMETERS 76
THIRD-PARTY AUDIO SERVICE ACCESS MODULE 64
AUDIO RENDER REQUEST 68
AUDIO TUNING PARAMETERS 76
SERVER-SIDE DEDICATED AUDIO PROCESSOR 66
AUDIO RENDERING SOFTWARE 70
FIRST-PARTY SOFTWARE 72
THIRD-PARTY SOFTWARE 74
SET OF CLIENT AUDIO PARAMETERS 32
SET OF AUDIO TUNING PARAMETERS 76
3RD PARTY AUDIO SERVER 78

FIG. 3

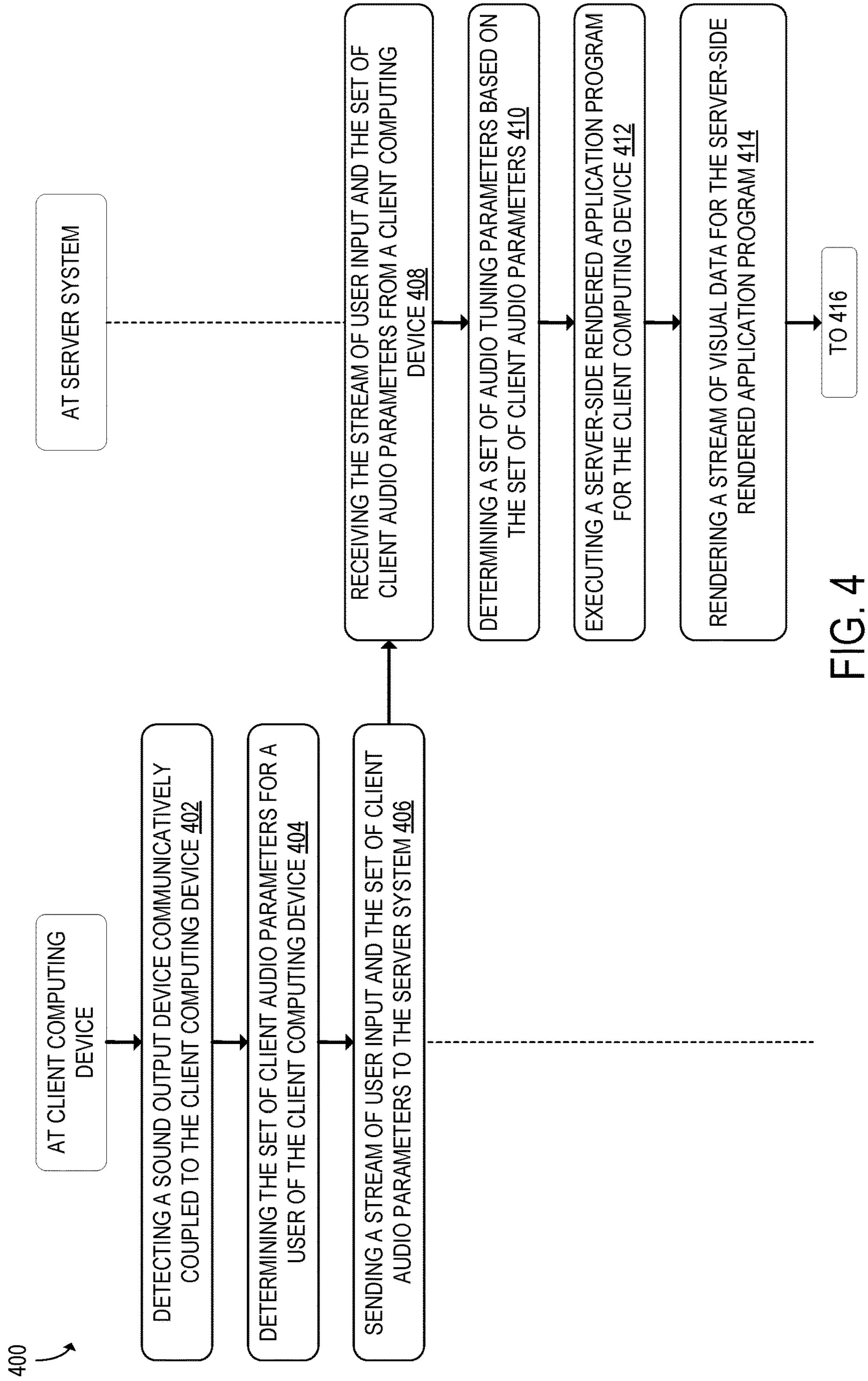
400
AT CLIENT COMPUTING DEVICE
DETECTING A SOUND OUTPUT DEVICE COMMUNICATIVELY COUPLED TO THE CLIENT COMPUTING DEVICE 402
DETERMINING THE SET OF CLIENT AUDIO PARAMETERS FOR A USER OF THE CLIENT COMPUTING DEVICE 404
SENDING A STREAM OF USER INPUT AND THE SET OF CLIENT AUDIO PARAMETERS TO THE SERVER SYSTEM 406
AT SERVER SYSTEM
RECEIVING THE STREAM OF USER INPUT AND THE SET OF CLIENT AUDIO PARAMETERS FROM A CLIENT COMPUTING DEVICE 408
DETERMINING A SET OF AUDIO TUNING PARAMETERS BASED ON THE SET OF CLIENT AUDIO PARAMETERS 410
EXECUTING A SERVER-SIDE RENDERED APPLICATION PROGRAM FOR THE CLIENT COMPUTING DEVICE 412
RENDERING A STREAM OF VISUAL DATA FOR THE SERVER-SIDE RENDERED APPLICATION PROGRAM 414
TO 416

FIG. 4

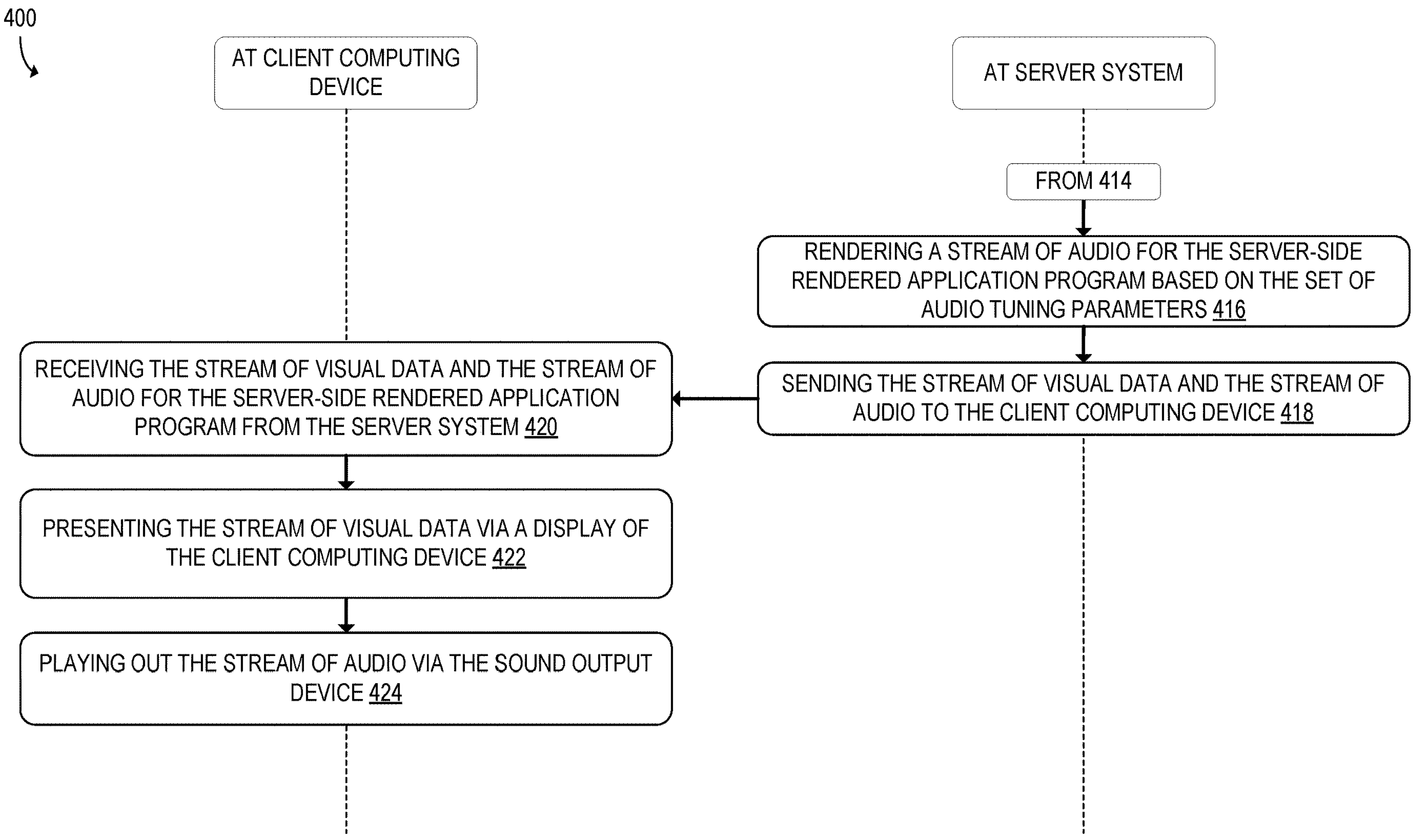
400
AT CLIENT COMPUTING DEVICE
AT SERVER SYSTEM
FROM 414
RENDERING A STREAM OF AUDIO FOR THE SERVER-SIDE RENDERED APPLICATION PROGRAM BASED ON THE SET OF AUDIO TUNING PARAMETERS 416
SENDING THE STREAM OF VISUAL DATA AND THE STREAM OF AUDIO TO THE CLIENT COMPUTING DEVICE 418
RECEIVING THE STREAM OF VISUAL DATA AND THE STREAM OF AUDIO FOR THE SERVER-SIDE RENDERED APPLICATION PROGRAM FROM THE SERVER SYSTEM 420
PRESENTING THE STREAM OF VISUAL DATA VIA A DISPLAY OF THE CLIENT COMPUTING DEVICE 422
PLAYING OUT THE STREAM OF AUDIO VIA THE SOUND OUTPUT DEVICE 424

FIG. 5

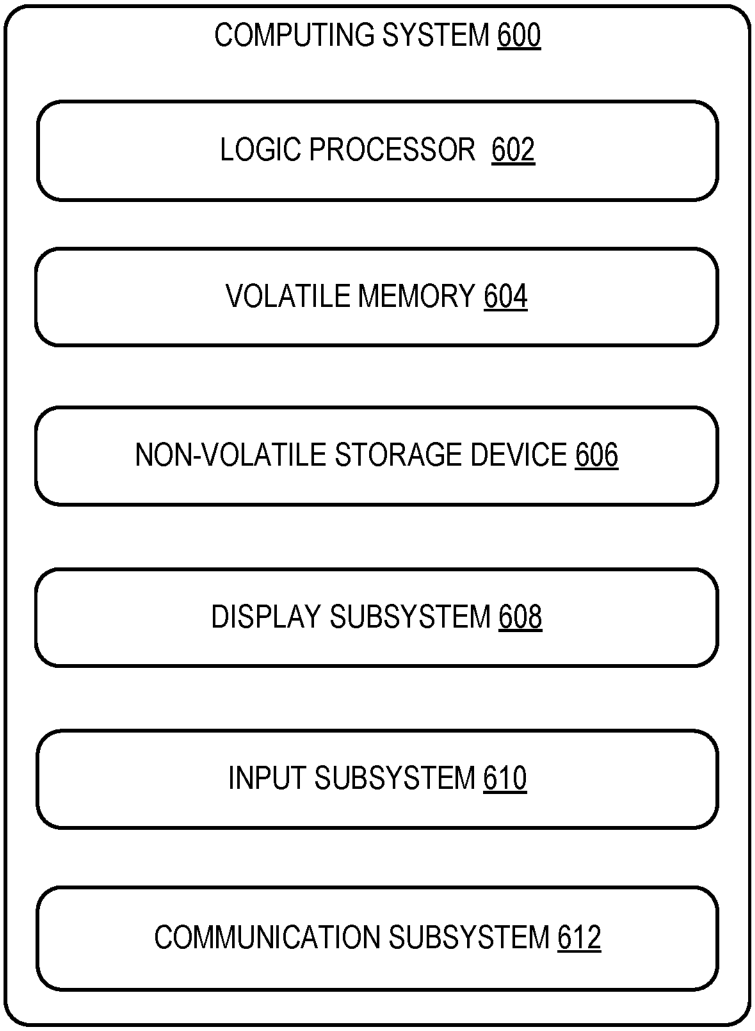
COMPUTING SYSTEM 600
LOGIC PROCESSOR 602
VOLATILE MEMORY 604
NON-VOLATILE STORAGE DEVICE 606
DISPLAY SUBSYSTEM 608
INPUT SUBSYSTEM 610
COMMUNICATION SUBSYSTEM 612

FIG. 6

SERVER-SIDE RENDERED AUDIO USING CLIENT AUDIO PARAMETERS

BACKGROUND

Thin client computing devices and mobile computing devices often lack the processor power required to run applications that have high CPU and GPU requirements. However, server-side rendering techniques that execute these applications on a cloud platform and provide the rendered visuals and audio for the application to the client computing device may allow users to engage with these applications even though their client computing device does not meet the required hardware specifications for that application.

SUMMARY

A server system is provided. The server system may comprise at least one processor configured to receive a set of client audio parameters from a client computing device, determine a set of audio tuning parameters based on the set of client audio parameters, execute a server-side rendered application program for the client computing device, render a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device, render a stream of audio for the server-side rendered application program based on the set of audio tuning parameters, and send the stream of visual data and the stream of audio to the client computing device.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to implementations that solve any or all disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic view of an example computing system for rendering visual data and audio for a server-side rendered application program according to one embodiment of the present disclosure.

FIG. **2** shows a schematic view of a client computing device of the example computing system of FIG. **1**.

FIG. **3** shows a schematic view of a server system of the example computing system of FIG. **1**.

FIG. **4** shows an example method for rendering visual data and audio for a server-side rendered application program that may be implemented by the computing system of FIG. **1**.

FIG. **5** continues the example method of FIG. **4**.

FIG. **6** shows a schematic view of an example computing environment in which the computing device of FIG. **1** may be enacted.

DETAILED DESCRIPTION

FIG. **1** illustrates a computing system **10** that presents visuals and audio for a server-side rendered application program **12** to a user of a client computing device **14**. As illustrated, a processor **16** of the client computing device may be configured to execute a client application program **18** that communicates with a server system **20** of the computer system **10**. In one example, the server system **20** include a plurality of server computing devices **22** that are collectively configured to operate in a cloud computing configuration. Each server computing device **22** may be configured to execute separate instances of the server-side rendering application program **12**, which may each be associated with separate client computing devices **14**. In one specific example, the server-side rendered application program **12** may take the form of a game application. However, it should be appreciated that the server-side rendered application program **12** may take other suitable forms, such as, for example, an audio or music application that does not include server-side rendered visuals.

FIG. **2** illustrates an example client computing device **14** that is configured to communicate with the server system **20**. The client computing device **14** may include a processor **16**, volatile and non-volatile storage devices **24**, one or more input devices **26**, a display **28**, a sound output device **30**, and other suitable computing components. In one example, the client computing device **14** may take the form of a mobile computing device such as a smart phone having a capacitive touch display that includes both the input device **26** and the display **28**. In this example, the sound output device **30** may include speakers integrated into a housing of the mobile computing device. As another example, the sound output device **30** may include headphone or earbud devices that are coupled to the client computing device **14** by wired or wireless mediums. In another example, the client computing device **14** may take the form of a thin client computing device, a head mounted display device, or any other suitable type of computing device configured to present visuals and/or sound from a server-side rendered application program.

The processor **16** of the client computing device **14** may be configured to execute the client application program **18** that is associated with the server-side rendered application program **12** executed by server computing devices **22** of the server system **20**. The client application program **18** may include a graphical user interface (GUI) that is presented via the display **28**. The user may interact with the client application program **18** via the one or more input devices **26** of the client computing device **14**, and rendered visuals and sound for the server-side rendered application program **12** may be presented via the GUI of the client application program **18**. Application logic, application state, and application rendering may be handled in the background by one or more server computing devices **22** of the server system **20** and presented via client application program **18** executed on the client computing device **14**.

To render audio that is tuned for the client computing device **14** of the user, the client application program **18** may be configured to determine a set of client audio parameters **32** for a user of the client computing device **14**. The set of client audio parameters **32** may include one or more different types of audio parameters. In one example, the client application program **18** may be configured to detect the sound output device **30** communicatively coupled to the client computing device **14**, and determine one or more different types of client audio parameters based on the detected sound output device **30**. In one example, the set of client audio parameters **32** includes an indication **34** of whether a sound output device **30** is currently communicatively coupled to the client computing device **14**. If a sound output device **30** is not currently coupled to the client computing device **14**, then network bandwidth and computing resources may be saved by halting sound rendering until a sound output device

30 is detected. The sound output device **30** may be communicatively coupled to the client computing device via wired or wireless mediums. The client application program **32** may be configured to store as audio parameters both the hardware identifier **36** of a known sound output device **30** that the user has coupled to the client computing device **14** previously, as well as the indication **34** of whether that known sound output device **30** is currently connected.

In another example, the set of audio parameters **32** may include a hardware identifier **36** for the sound output device **30**, such as, for example, a manufacturer serial number or another type of hardware identifier. The set of audio parameters **32** may also include a type of sound output device **30**, which may take the form of a headphone device, an earbud device, a home theater sound system, a speaker integrated in a housing of a mobile computing device, or any other suitable type of sound output device **30**.

Different sound output devices **30** may have different acoustic, geometric, and electronic characteristics that will affect audio playout. That is, the same audio signal may sound different depending on the characteristics of the sound output device **30**. In one example, the set of audio parameters **32** may include one or more characteristics **38** of the sound output device **30** such as, for example, a geometry, a frequency response, a sensitivity, and an impedance of the sound output device **30**. However, it should be appreciated that other characteristics **38** of the sound output device **30** may also be determined and included in the set of audio parameters **32**, such as a home theater setup/layout, a material of the speaker cone, a size of the speaker, and other speaker characteristics not specifically described above. The set of audio parameters **32** may also include other types of parameters, such as, for example, a listener orientation, an object size, an emitter shape, an emitter orientation, and other types of audio parameters that may be used to customize the streaming audio for the user's device.

In another example, the set of client audio parameters **32** may includes a hardware identifier **40** of the client computing device **14**, such as, for example, a manufacturer serial number or another type of hardware identifier **40**. The hardware identifier **40** may also include identifiers for computer components, such as, for example, a sound card or sound processing device of the client computing device **14**. The hardware identifier **40** may indicate a model of the client computing device **14**, such as, a particular model of a mobile computing device.

The client computing device **14** may store global user audio settings that are set by an operating system or audio driver executed by the processor **16** of the client computing device **14**. The client application program **18** may also include local user audio settings. These user audio settings may include, for example, volume, equalizer settings, sound/audio effects, and other types of audio settings. As illustrated in FIG. **2**, the set of audio parameters **32** may include user audios settings **42** selected by a user of the client computing device, which may include one or more of the global and/or local user audio settings.

The server system **20** may be configured to render a stream of audio **46** for the server-side rendered application program **12** using different types of audio rendering software **44**. For example, the stream of audio **46** may be rendered using a first-party audio rendering software of the server system **20**. As another example, the stream of audio **46** may be rendered using third-party audio rendering software, such as, for example, DOLBY ATMOS, DTS:X, and other third-party audio rendering software. As another example, the type of audio rendering software **44** may specify whether the stream of audio **46** should be rendered for headphones vs a home theater speaker system. In these examples, the set of audio parameters **32** may include the type of audio rendering software **44** for rendering the stream of audio **46** for the server-side rendered application program **12**. The type of audio rendering software **44** may be user selected or programmatically selected. For example, the type of audio rendering software **44** may be programmatically selected based on a hardware identifier **36** or characteristics **38** of the sound output device **30**. It should be appreciated that the types of audio rendering software **44** described above are merely exemplary, and that other types of audio rendering software **44** may be selected for rendering the stream of audio **46**.

As illustrated in FIG. **2**, the client application program **18** may be configured to determined one or more of the audio parameters described above, and send the set of client audio parameters **32** to the server system **20** configured to execute the server-side rendered application program **12** over a computer network **48**, which, for example, may be a Wide Area Network (WAN). It should be appreciated that the examples of audio parameters **32** described above are merely exemplary, and that other types of audio parameters **32** may be determined by the client application program **18** and sent to the server system **20**.

The client application program **18** may be configured to detect user input **50** received from the one or more input devices **26**. In a game application example, the user input **50** may be navigation input, GUI input, or other types of user input **50** for the server-side rendered application program **12**. The client computing device may be configured to send a stream of the user input **50** for the server-side rendered application program **12** to the server system **20**.

As will be discussed in more detail below, the server system **20** may render visual data **52** for the server-side rendered application program **12** based on an application state of the server-side rendered application program **12** and the stream of user input **50**. The server system **20** may also rendered a stream of audio **46** for the server-side rendered application program **12** based on the set of client audio parameters **32** and the application state of the server-side rendered application program **12**. The rendered visual data **52** and the rendered audio **46** may be sent to the client computing device **14** over the computer network **48**.

As illustrated in FIG. **2**, the client application program **18** may be configured to receive the stream of visual data **52** and the stream of audio **46** for the server-side rendered application program **12** from the server system **20**. The client application program **18** may be further configured to present the stream of visual data **52** via the display **28** of the client computing device **14**, and playout the stream of audio **46** via the sound output device **30**. In this manner, the user may interact with the server-side rendered application program **12** by entering user input **50** into the input device **26**, and view/hear corresponding visuals and audio of the server-side rendered application program **12**.

Turning back to FIG. **1**, the user input **50** and the set of client audio parameters **32** may be sent from the client computing device **14** to the server system **20**. The server system **20** may be configured to assign at least one processor **54** of a server computing device **22** of the server system **20** to execute an instance of the server-side rendered application program **12** for the client application program **18** of the client computing device **14**. The user input **50** and the set of client audio parameters **32** may be routed by the server system **20** to the assigned one or more processors **54**. In one example, the server-side rendered application program **12** may be executed within a virtualized computing environment that may use computing resources from a plurality of processors **54** and server computing devices **22** in a cloud computing configuration.

As illustrated in FIG. **1**, the server computing device **22** assigned to the client application program **18** executed by the client computing device **14** may be configured to receive the stream of user input **50** and the set of client audio parameters **32** from the client computing device **14**. The server-side rendered application program **12** may be configured to process the stream of user input **50** and the set of client audio parameters **32** to generate a stream of rendered audio **46** and rendered visual data **46** that is sent back to the client computing device **14**.

FIG. **3** illustrates a schematic view of a server computing device **22** of the server system **20**. As shown, the server computing device **22** may include at least one processor **54**, volatile and non-volatile storage devices **56**, and other suitable computing components. The at least one processor **54** may execute the server-side rendered application program **12**, which may include application state data **58**, a visual rendering module **60**, a sound module **62**, and a third-party audio service access module **64**. The application state data **58** may indicate a current state of the server-side rendered application program **12** for a current session with the client application program **18**, and may be updated in response to application logic of the server-side rendered application program **12** and the stream of user input **50** received from the client computing device. For example, in a game application, the application state data **58** may indicate a current state of the game world including a user's character that may be controlled based on the user input **50**.

The visual rendering module **60** may be configured to render a stream of visual data **52** for the server-side rendered application program **12** based on the application state data **58** and the stream of user input **50** received from the client computing device **14**. For example, the visual rendering module **60** may be configured to render sequential frames based on the application state data **58** at a predetermined frame rate.

The sound module **62** may be configured to generate rendered audio **46** based on the application state data **58** that is synced with the rendered visual data **46**. In one example, the audio **46** may be rendered by the at least one processor **54** of the server computing device **22**. In another example, the server system **20** may further include a server-side dedicated audio processor **66** that may be configured to render the audio **46** for the server-side rendered application program **12**. In this example, the sound module **62** may send an audio render request **68** to the server-side dedicated audio processor **66** that includes sound data from the application state data **58** that will be rendered by the server-side dedicated audio processor **66**. Rendering audio using the dedicated audio processor **66** may reduce the computational burden on the at least one processor of the server computing device **22**.

The sound data may be rendered using audio rendering software **70**. In one example, the audio rendering software **12** may be first-party software **72**. In another example, the audio rendering software **70** may be third-party software **74** that is developed and owned by a third party, such as, for example, DOLBY ATMOS, DTS:X, etc. In one example, to tune the audio rendering software **70** for the sound output device **30** and user settings of the client computing device **14**, the sound module **62** may be configured to determine a set of audio tuning parameters **76** based on the set of client audio parameters **32**.

The audio rendering software **70** that is executed by either the at least one processor **54** of the server computing device **22** or the server-side dedicated audio processor **66** may be configured to render the stream of audio **46** for the server-side rendered application program **12** based on the set of audio tuning parameters **76**. For example, the audio rendering software **70** may use the audio tuning parameters **76** to determine how transforms for the audio will be performed during rendering. In this manner, the audio **46** may be rendered to suit the specific characteristics of the user's sound output device **30** and the user's audio settings. For example, the audio **46** may be rendered based on equalization levels set by the user. As another example, the audio may be rendered as stereo audio for headphone sound output devices, or as surround sound audio for home theater speaker sound output devices.

As yet another example, the audio may be rendered to differently based on the specific speaker cone geometry or material of the sound output device **30**. As yet another example, specific audio tuning parameters **76** may be predetermined for specific hardware identifiers of client computing devices **14** and sound output devices **30**. That is, the manufacturers of the client computing device **14** and sound output device **30** may work with the developers of the audio rendering software **70** to develop as set of audio tuning parameters **76** that are suitable for a particular sound output device **30** or client computing device **14**.

In one example, the audio rendering software **70** is first-party software **72**, and the sound module **62** of the server-side rendered application program **12** may be configured to determine the set of audio tuning parameters **76**. In another example, the audio rendering software **70** is third-party software **74**, and the audio tuning parameters **76** may be generated by a third-party audio server **78**. For example, the third-party software **74** may be DOLBY ATMOS, and the third-party audio server **78** may be a DOLBY server that may be accessed by the third-party audio service access module **64** of the server-side rendered application program. In this example, the third-party audio service access module **64** may be configured to send the set of client audio parameters **32** to the third-party audio server **78**, and receive the set of audio tuning parameters **76** from the third-party audio server **78**.

In one example, the audio rendering software **70** may include a plurality of different first-party and third-party audio rendering software. For example, the audio rendering software **70** may include DOLBY ATMOS audio rendering software, DTS:X audio rendering software, etc. As discussed previously, the set of client audio parameters **32** may indicate the type of audio rendering software **44** that is to be used to render the audio. Each of these types of audio rendering software **44** may have different associated third-party audio servers **78** that may be accessed to obtain audio tuning parameters **76** for that audio rendering software. In this example, the third-party audio service access module **64** may be configured to select the third-party audio server **78** from among a plurality of third-party audio servers **78** based on the type of audio rendering software **44** in the set of client audio parameters **32**. The third-party audio service access module **64** may then send the client audio parameters **32** to the selected third-party audio server **78**, and receive the set of audio tuning parameters **76** that may be used to tune the audio rendering software **70** for rendering the stream of audio **46** for the server-side rendered application program **12**.

As illustrated in FIG. **1**, the server computing device **22** may send the stream of visual data **52** and the stream of audio **46** to the client computing device **14** for presentation to the user. During the session, the user may continue to enter user input **50** that is sent to the server computing device **22**, and the server computing device **22** may render visual data **52** and audio **46** based on that user input **50** that is sent back to the client computing device **14**. In this manner, the user of the client computing device **14** may engage with the content of the server-side rendered application program **12** using their client computing device **14**.

FIG. **4** shows a flowchart for a computer implemented method **400** for presenting visuals and audio for a server-side rendered application program to a user. At **402**, at a processor of a client computing device, the method **400** may include detecting a sound output device communicatively coupled to the client computing device. The sound output device may take the form of a headphone device, an earbud device, a speaker device, a home theater sound system, or another suitable type of sound output device. The sound output device may be communicatively coupled to the client computing device via wired or wireless mediums.

At **404**, the method **400** may include determining a set of client audio parameters for a user of the client computing device. In one example, the set of client audio parameters may include a hardware identifier for a sound output device communicatively coupled to the client computing device. In another example, the set of client audio parameters may include a characteristic of the sound output device such as, for example, a geometry, a frequency response, a sensitivity, an impedance, or other characteristics of the sound output device. Other example client audio parameters that may be determined at step **404** are discussed above with reference to FIG. **1**.

At **406**, the method **400** may include sending a stream of user input and the set of client audio parameters to a server system. The stream of user input may be received via one or more input devices of the client computing device. The stream of user input and the set of client audio parameters may be sent to the server system over a computer network, such as, for example, a Wide Area Network.

At **408**, at a processor of a server system, the method **400** may include receiving the stream of user input and the set of client audio parameters from the client computing device.

At **410**, the method **400** may include determining a set of audio tuning parameters based on the set of client audio parameters. The set of audio tuning parameters may be used to configure audio rendering software to determine how transforms for the audio will be performed during rendering. In this manner, the audio may be rendered to suit the specific characteristics of the user's sound output device and the user's audio settings. For example, the audio may be rendered based on equalization levels set by the user. As another example, the audio may be rendered as stereo audio for headphone sound output devices, or as surround sound audio for home theater speaker sound output devices. Additional examples of audio tuning parameters are discussed above with reference to FIG. **3**.

At **412**, the method **400** may include executing a server-side rendered application program for the client computing device. The server-side rendered application program may be executed by at least one processor of a server computing device of the server system. The server-side rendered application program may render visuals and audio that are provided to a client application program for presentation to a user.

At **414**, the method **400** may include rendering a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device. The server-side rendered application program may include an application state that is determined based on the stream of user input. For example, the server-side rendered application program may take the form of a game application, and the application state may indicate a current state of the game world and a user's character that is controlled via the user input. The server-side rendered application program may rendered visual frames based on the current application state at a predetermined frame rate.

At **416**, the method **400** may include rendering a stream of audio for the server-side rendered application program based on the set of audio tuning parameters. In one example, rendering the stream of audio for the server-side rendered application program based on the set of audio tuning parameters may be performed by a server-side dedicated audio processor of the server system. In another example, the server computing device may perform the audio rendering.

As discussed above with reference to FIG. **3**, the audio may be rendered using third-party audio rendering software. In this example, the audio tuning parameters for the third-party audio rendering software may be determined at least in part by sending the set of client audio parameters to a third-party audio server, and receiving the set of audio tuning parameters from the third-party audio server, the set of audio tuning parameters being determined based on the set of client audio parameters. The received audio tuning parameters may be used to configure the third-party audio rendering software for rendering the audio at step **416**.

At **418**, the method **400** may include sending the stream of visual data and the stream of audio to the client computing device. The stream of visual data and the stream of audio may be sent over the computer network.

At **420**, at the client computing device, the method **400** may include receiving the stream of visual data and the stream of audio for the server-side rendered application program from the server system. At **422**, the method **400** may include presenting the stream of visual data via a display of the client computing device. At **424**, the method **400** may include playing out the stream of audio via the sound output device.

In the method **400**, the user may continue to enter user input that is sent to the server system at step **406**, and the server system may continue to render visual data based on the user input at step **414** and corresponding audio at step **416**. The stream of visual data and rendered audio may be streamed to the client computing device such that the user may enter input and be presented with corresponding visual data and audio.

In some embodiments, the methods and processes described herein may be tied to a computing system of one or more computing devices. In particular, such methods and processes may be implemented as a computer-application program or service, an application-programming interface (API), a library, and/or other computer-program product.

FIG. **6** schematically shows a non-limiting embodiment of a computing system **600** that can enact one or more of the methods and processes described above. Computing system **600** is shown in simplified form. Computing system **600** may embody the client computing device **14** and the server computing devices **22** described above and illustrated in FIG. **1**. Computing system **600** may take the form of one or more personal computers, server computers, tablet computers, home-entertainment computers, network computing devices, gaming devices, mobile computing devices, mobile communication devices (e.g., smart phone), and/or other computing devices, and wearable computing devices such as smart wristwatches and head mounted augmented reality devices.

Computing system **600** includes a logic processor **602** volatile memory **604**, and a non-volatile storage device **606**. Computing system **600** may optionally include a display subsystem **608**, input subsystem **610**, communication subsystem **612**, and/or other components not shown in FIG. **6**.

Logic processor **602** includes one or more physical devices configured to execute instructions. For example, the logic processor may be configured to execute instructions that are part of one or more applications, programs, routines, libraries, objects, components, data structures, or other logical constructs. Such instructions may be implemented to perform a task, implement a data type, transform the state of one or more components, achieve a technical effect, or otherwise arrive at a desired result.

The logic processor may include one or more physical processors (hardware) configured to execute software instructions. Additionally or alternatively, the logic processor may include one or more hardware logic circuits or firmware devices configured to execute hardware-implemented logic or firmware instructions. Processors of the logic processor **602** may be single-core or multi-core, and the instructions executed thereon may be configured for sequential, parallel, and/or distributed processing. Individual components of the logic processor optionally may be distributed among two or more separate devices, which may be remotely located and/or configured for coordinated processing. Aspects of the logic processor may be virtualized and executed by remotely accessible, networked computing devices configured in a cloud-computing configuration. In such a case, these virtualized aspects are run on different physical logic processors of various different machines, it will be understood.

Non-volatile storage device **606** includes one or more physical devices configured to hold instructions executable by the logic processors to implement the methods and processes described herein. When such methods and processes are implemented, the state of non-volatile storage device **606** may be transformed—e.g., to hold different data.

Non-volatile storage device **606** may include physical devices that are removable and/or built-in. Non-volatile storage device **606** may include optical memory (e.g., CD, DVD, HD-DVD, Blu-Ray Disc, etc.), semiconductor memory (e.g., ROM, EPROM, EEPROM, FLASH memory, etc.), and/or magnetic memory (e.g., hard-disk drive, floppy-disk drive, tape drive, MRAM, etc.), or other mass storage device technology. Non-volatile storage device **606** may include nonvolatile, dynamic, static, read/write, read-only, sequential-access, location-addressable, file-addressable, and/or content-addressable devices. It will be appreciated that non-volatile storage device **606** is configured to hold instructions even when power is cut to the non-volatile storage device **606**.

Volatile memory **604** may include physical devices that include random access memory. Volatile memory **604** is typically utilized by logic processor **602** to temporarily store information during processing of software instructions. It will be appreciated that volatile memory **604** typically does not continue to store instructions when power is cut to the volatile memory **604**.

Aspects of logic processor **602**, volatile memory **604**, and non-volatile storage device **606** may be integrated together into one or more hardware-logic components. Such hardware-logic components may include field-programmable gate arrays (FP GAs), program- and application-specific integrated circuits (PASIC/ASICs), program- and application-specific standard products (PSSP/ASSPs), system-on-a-chip (SOC), and complex programmable logic devices (CPLDs), for example.

The terms "module," "program," and "engine" may be used to describe an aspect of computing system **600** typically implemented in software by a processor to perform a particular function using portions of volatile memory, which function involves transformative processing that specially configures the processor to perform the function. Thus, a module, program, or engine may be instantiated via logic processor **602** executing instructions held by non-volatile storage device **606**, using portions of volatile memory **604**. It will be understood that different modules, programs, and/or engines may be instantiated from the same application, service, code block, object, library, routine, API, function, etc. Likewise, the same module, program, and/or engine may be instantiated by different applications, services, code blocks, objects, routines, APIs, functions, etc. The terms "module," "program," and "engine" may encompass individual or groups of executable files, data files, libraries, drivers, scripts, database records, etc.

When included, display subsystem **608** may be used to present a visual representation of data held by non-volatile storage device **606**. The visual representation may take the form of a graphical user interface (GUI). As the herein described methods and processes change the data held by the non-volatile storage device, and thus transform the state of the non-volatile storage device, the state of display subsystem **608** may likewise be transformed to visually represent changes in the underlying data. Display subsystem **608** may include one or more display devices utilizing virtually any type of technology. Such display devices may be combined with logic processor **602**, volatile memory **604**, and/or non-volatile storage device **606** in a shared enclosure, or such display devices may be peripheral display devices.

When included, input subsystem **610** may comprise or interface with one or more user-input devices such as a keyboard, mouse, touch screen, or game controller. In some embodiments, the input subsystem may comprise or interface with selected natural user input (NUI) componentry. Such componentry may be integrated or peripheral, and the transduction and/or processing of input actions may be handled on- or off-board. Example NUI componentry may include a microphone for speech and/or voice recognition; an infrared, color, stereoscopic, and/or depth camera for machine vision and/or gesture recognition; a head tracker, eye tracker, accelerometer, and/or gyroscope for motion detection and/or intent recognition; as well as electric-field sensing componentry for assessing brain activity; and/or any other suitable sensor.

When included, communication subsystem **612** may be configured to communicatively couple various computing devices described herein with each other, and with other devices. Communication subsystem **612** may include wired and/or wireless communication devices compatible with one or more different communication protocols. As non-limiting examples, the communication subsystem may be configured for communication via a wireless telephone network, or a wired or wireless local- or wide-area network, such as a HDMI over Wi-Fi connection. In some embodiments, the communication subsystem may allow computing system **600** to send and/or receive messages to and/or from other devices via a network such as the Internet.

The following paragraphs provide additional support for the claims of the subject application. One aspect provides a server system comprising at least one processor. The at least one processor is configured to receive a set of client audio parameters from a client computing device, determine a set of audio tuning parameters based on the set of client audio parameters, execute a server-side rendered application program for the client computing device, render a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device, render a stream of audio for the server-side rendered application program based on the set of audio tuning parameters, and send the stream of visual data and the stream of audio to the client computing device. In this aspect, additionally or alternatively, the server system may further comprise a server-side dedicated audio processor configured to render the stream of audio for the server-side rendered application program based on the set of audio tuning parameters. In this aspect, additionally or alternatively, the rendered stream of audio for the server-side rendered application program may be rendered as stereo audio. In this aspect, additionally or alternatively, to determine the set of audio tuning parameters, the at least one processor may be further configured to send the set of client audio parameters to a third-party audio server, and receive the set of audio tuning parameters from the third-party audio server, the set of audio tuning parameters being determined based on the set of client audio parameters. In this aspect, additionally or alternatively, the set of client audio parameters may include a type of audio rendering software for rendering the stream of audio for the server-side rendered application program, and the at least one processor may be further configured to select the third-party audio server from among a plurality of third-party audio servers based on the type of audio rendering software in the set of client audio parameters. In this aspect, additionally or alternatively, the set of client audio parameters may include a hardware identifier for the client computing device. In this aspect, additionally or alternatively, the set of client audio parameters may include a hardware identifier for a sound output device communicatively coupled to the client computing device. In this aspect, additionally or alternatively, the sound output device may be selected from the group consisting of a headphone device, an earbud device, a speaker device, and a home theater sound system. In this aspect, additionally or alternatively, the set of client audio parameters may include a characteristic of the sound output device selected from the group consisting of a geometry, a frequency response, a sensitivity, and an impedance. In this aspect, additionally or alternatively, the set of client audio parameters may include a user audio setting selected by a user of the client computing device. In this aspect, additionally or alternatively, the set of client audio parameters may include an indication of whether a sound output device is currently communicatively coupled to the client computing device. In this aspect, additionally or alternatively, the at least one processor may be configured to communicate with a client application executed by a processor of the client computing device. The client application may be configured to cause the processor to detect a sound output device communicatively coupled to the client computing device, determine the set of client audio parameters for a user of the client computing device, send the set of client audio parameters to the server system, send the stream of user input for the server-side rendered application program to the server system, receive the stream of visual data and the stream of audio for the server-side rendered application program from the server system, present the stream of visual data via a display of the client computing device, and playout the stream of audio via the sound output device.

Another aspect provides a method comprising, at a processor of a server system, receiving a set of client audio parameters from a client computing device, determining a set of audio tuning parameters based on the set of client audio parameters, executing a server-side rendered application program for the client computing device, rendering a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device, rendering a stream of audio for the server-side rendered application program based on the set of audio tuning parameters, and sending the stream of visual data and the stream of audio to the client computing device. In this aspect, additionally or alternatively, rendering the stream of audio for the server-side rendered application program based on the set of audio tuning parameters may be performed by a server-side dedicated audio processor of the server system. In this aspect, additionally or alternatively, determining the set of audio tuning parameters may further comprises sending the set of client audio parameters to a third-party audio server, and receiving the set of audio tuning parameters from the third-party audio server, the set of audio tuning parameters being determined based on the set of client audio parameters. In this aspect, additionally or alternatively, the method may further comprise, at a processor of the client computing device, detecting a sound output device communicatively coupled to the client computing device, determining the set of client audio parameters for a user of the client computing device, sending the set of client audio parameters to the server system, sending the stream of user input for the server-side rendered application program to the server system, receiving the stream of visual data and the stream of audio for the server-side rendered application program from the server system, presenting the stream of visual data via a display of the client computing device, and playing out the stream of audio via the sound output device. In this aspect, additionally or alternatively, the set of client audio parameters may include a hardware identifier for a sound output device communicatively coupled to the client computing device. In this aspect, additionally or alternatively, the sound output device may be selected from the group consisting of a headphone device, an earbud device, a speaker device, and a home theater sound system. In this aspect, additionally or alternatively, the set of client audio parameters may include a characteristic of the sound output device selected from the group consisting of a geometry, a frequency response, a sensitivity, and an impedance.

Another aspect provides a server system comprising at least one processor. The at least one processor is configured to receive a set of client audio parameters from a client computing device, determine a set of audio tuning parameters based on the set of client audio parameters, execute a server-side rendered application program for the client computing device, render a stream of audio for the server-side rendered application program based on the set of audio tuning parameters, and send the stream of audio to the client computing device.

It will be understood that the configurations and/or approaches described herein are exemplary in nature, and that these specific embodiments or examples are not to be considered in a limiting sense, because numerous variations are possible. The specific routines or methods described herein may represent one or more of any number of processing strategies. As such, various acts illustrated and/or described may be performed in the sequence illustrated and/or described, in other sequences, in parallel, or omitted. Likewise, the order of the above-described processes may be changed.

The subject matter of the present disclosure includes all novel and non-obvious combinations and sub-combinations of the various processes, systems and configurations, and other features, functions, acts, and/or properties disclosed herein, as well as any and all equivalents thereof.

The invention claimed is:

1. A server system comprising:

at least one processor configured to:

execute a server-side rendered application program for a client computing device;

receive a set of client audio parameters from the client computing device, wherein the set of client audio parameters indicates at least a type of audio rendering software for rendering a stream of audio for the server-side rendered application program;

select a third-party audio server from among a plurality of third-party audio servers based on the type of audio rendering software indicated by the set of client audio parameters;

send one or more client audio parameters of the set to the selected third-party audio server;

receive a set of audio tuning parameters from the selected third-party audio server based on the one or more client audio parameters sent to the selected third-party audio server;

render a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device;

render the stream of audio for the server-side rendered application program based on the set of audio tuning parameters; and

send the stream of visual data and the stream of audio to the client computing device.

2. The server system of claim **1**, wherein the server system further comprises a server-side dedicated audio processor configured to render the stream of audio for the server-side rendered application program based on the set of audio tuning parameters.

3. The server system of claim **1**, wherein the rendered stream of audio for the server-side rendered application program is rendered as stereo audio.

4. The server system of claim **1**, wherein the set of client audio parameters includes a hardware identifier for the client computing device.

5. The server system of claim **1**, wherein the set of client audio parameters includes a hardware identifier for a sound output device communicatively coupled to the client computing device.

6. The server system of claim **5**, wherein the sound output device is selected from the group consisting of a headphone device, an earbud device, a speaker device, and a home theater sound system.

7. The server system of claim **1**, wherein the set of client audio parameters includes a characteristic of the sound output device selected from the group consisting of a geometry, a frequency response, a sensitivity, and an impedance.

8. The server system of claim **1**, wherein the set of client audio parameters includes a user audio setting selected by a user of the client computing device.

9. The server system of claim **1**, wherein the set of client audio parameters includes an indication of whether a sound output device is currently communicatively coupled to the client computing device.

10. The server system of claim **1**, wherein the at least one processor is configured to communicate with a client application executed by the client computing device, the client application being configured to cause the client computing device to:

detect a sound output device communicatively coupled to the client computing device;

determine the set of client audio parameters for a user of the client computing device;

send the set of client audio parameters to the server system;

send the stream of user input for the server-side rendered application program to the server system;

receive the stream of visual data and the stream of audio for the server-side rendered application program from the server system;

present the stream of visual data via a display of the client computing device; and

playout the stream of audio via the sound output device.

11. A method comprising:

at a processor of a server system:

executing a server-side rendered application program for a client computing device;

receiving a set of client audio parameters from the client computing device, wherein the set of client audio parameters indicates at least a type of audio rendering software for rendering a stream of audio for the server-side rendered application program;

selecting a third-party audio server from among a plurality of third-party audio servers based on the type of audio rendering software indicated by the set of client audio parameters;

sending one or more client audio parameters of the set to the selected third-party audio server;

receiving a set of audio tuning parameters from the selected third-party audio server based on the one or more client audio parameters sent to the selected third-party audio server;

rendering a stream of visual data for the server-side rendered application program based on a stream of user input received from the client computing device;

rendering the stream of audio for the server-side rendered application program based on the set of audio tuning parameters; and

sending the stream of visual data and the stream of audio to the client computing device.

12. The method of claim **11**, wherein rendering the stream of audio for the server-side rendered application program based on the set of audio tuning parameters is performed by a server-side dedicated audio processor of the server system.

13. The method of claim **11**, further comprising:

at a processor of the client computing device:

detecting a sound output device communicatively coupled to the client computing device;

determining the set of client audio parameters for a user of the client computing device;

sending the set of client audio parameters to the server system;

sending the stream of user input for the server-side rendered application program to the server system;

receiving the stream of visual data and the stream of audio for the server-side rendered application program from the server system;

presenting the stream of visual data via a display of the client computing device; and

playing out the stream of audio via the sound output device.

14. The method of claim **11**, wherein the set of client audio parameters includes a hardware identifier for a sound output device communicatively coupled to the client computing device.

15. The method of claim **14**, wherein the sound output device is selected from the group consisting of a headphone device, an earbud device, a speaker device, and a home theater sound system.

16. The method of claim **11**, wherein the set of client audio parameters includes a characteristic of the sound output device selected from the group consisting of a geometry, a frequency response, a sensitivity, and an impedance.

17. A server system comprising:

at least one processor configured to:

execute a server-side rendered application program for a client computing device;

receive a set of client audio parameters from the client computing device, wherein the set of client audio parameters indicates at least a type of audio rendering software for rendering a stream of audio for the server-side rendered application program;

select a third-party audio server from among a plurality of third-party audio servers based on the type of audio rendering software indicated by the set of client audio parameters;

send one or more client audio parameters of the set to the selected third- party audio server;

receive a set of audio tuning parameters from the selected third-party audio server based on the one or more client audio parameters sent to the selected third-party audio server;

render the stream of audio for the server-side rendered application program based on the set of audio tuning parameters; and

send the stream of audio to the client computing device.

18. The server system of claim **17**, wherein the server system further comprises a server-side dedicated audio processor configured to render the stream of audio for the server-side rendered application program based on the set of audio tuning parameters.

19. The server system of claim **17**, wherein the set of client audio parameters includes a hardware identifier for the client computing device.

20. The server system of claim **17**, wherein the set of client audio parameters includes a hardware identifier for a sound output device communicatively coupled to the client computing device.

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